US005360005A

United States Patent [19]

Wilk

[11] Patent Number: 5,360,005

[45] Date of Patent: Nov. 1, 1994

[54] MEDICAL DIAGNOSIS DEVICE FOR SENSING CARDIAC ACTIVITY AND BLOOD FLOW

[76] Inventor: **Peter J. Wilk**, 185 W. End Ave., New York, N.Y. 10023

[21] Appl. No.: **865,991**

[22] Filed: **Apr. 9, 1992**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 819,120, Jan. 10, 1992.

[51] **Int. Cl.**[5] **A61B 5/00**; A61B 8/06

[52] **U.S. Cl.** **128/653.1**; 128/661.08; 128/670; 128/773

[58] **Field of Search** 128/653.1, 660.01, 661.08, 128/662.03, 662.04, 661.1, 660.02, 739, 773, 670, 695; 381/150-151, 205, 169, 188

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,437,161	5/1984	Anderson .	
4,515,164	5/1985	Slavin	128/661.08
4,641,349	2/1987	Flom et al. .	
4,667,335	5/1987	Deindoerfer .	
4,770,189	9/1988	Shyu	128/773
4,777,961	10/1988	Saltzman	128/773
4,792,145	12/1988	Eisenberg et al.	128/773
4,838,681	6/1989	Pavlidis .	
4,839,822	6/1989	Dormond et al. .	
4,878,501	11/1989	Shue	128/773
4,947,245	8/1990	Ogawa et al. .	
4,981,139	1/1991	Pfohl	128/773
4,989,083	1/1991	Eino .	
5,022,402	6/1991	Schieberl et al.	128/773
5,022,405	6/1991	Hök et al.	128/653.1
5,025,809	6/1991	Johnson et al.	128/773
5,027,825	7/1991	Phelps, Sr. et al.	128/773
5,086,776	2/1992	Fowler, Jr. et al.	128/661.08
5,140,988	8/1992	Stouffer et al. .	

FOREIGN PATENT DOCUMENTS

3011770	10/1980	Germany	128/773

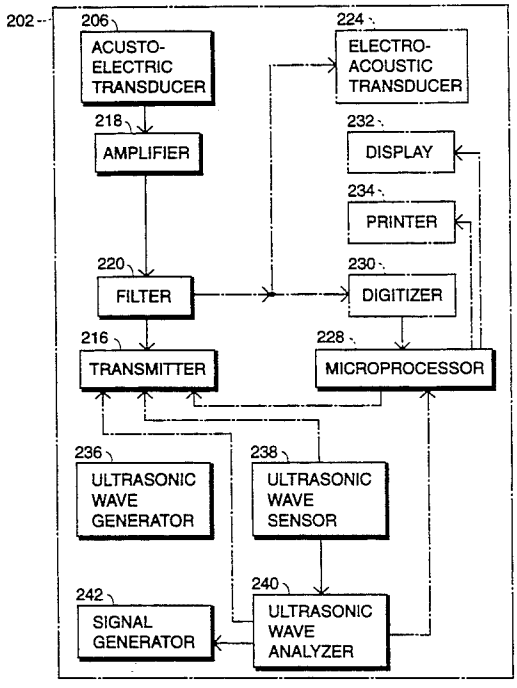
Primary Examiner—K. M. Pfaffle

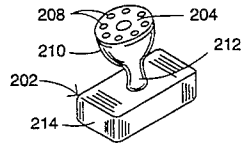
Attorney, Agent, or Firm—R. Neil Sudol; Henry D. Coleman

[57] **ABSTRACT**

A medical diagnostic method comprises the steps of automatically sensing an acoustic vibration inside a person, converting the sensed acoustic vibration to an electrical signal, amplifying the electrical signal, and converting the amplified electrical signal to an acoustic pressure wave. The steps of sensing and converting the sensed acoustic vibration to an electrical signal are implemented by operating an acoustoelectric transducer in a hand held device, and the method further comprises the step of holding the hand held device against a skin surface of the person. The method further comprises the steps of wirelessly transmitting the amplified signal to a receiver and printing or displaying the transmitted acoustic information after a processing thereof. The acoustic information or the processed information derived therefrom is advantageously printed in graphic form. Original acoustic information or processed information may be stored for subsequent use in diagnosing a patient. In another embodiment, the device is further provided with an ultrasonic generator, sensor, and processing circuitry for providing an indication of moving fluid, such as blood.

7 Claims, 5 Drawing Sheets





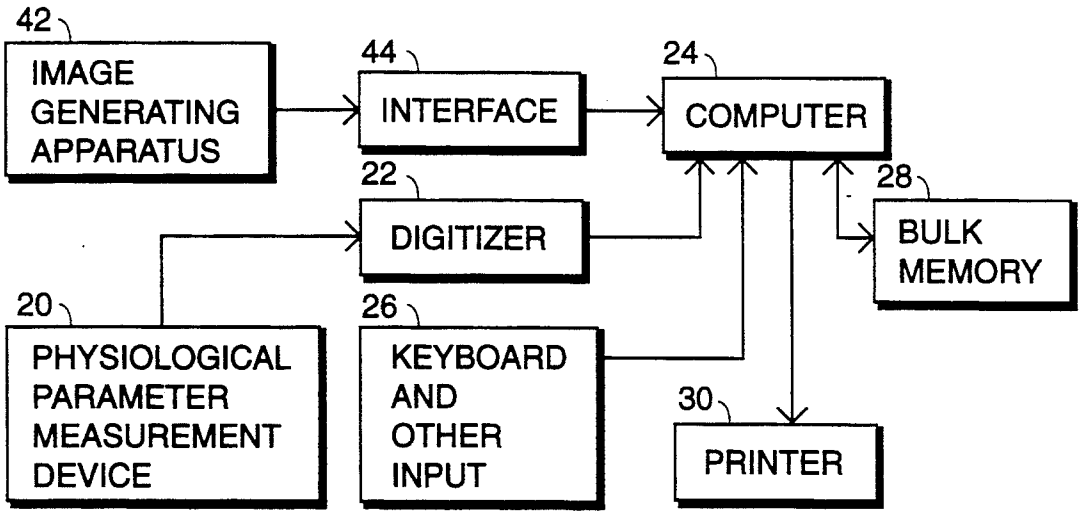


FIG. 1

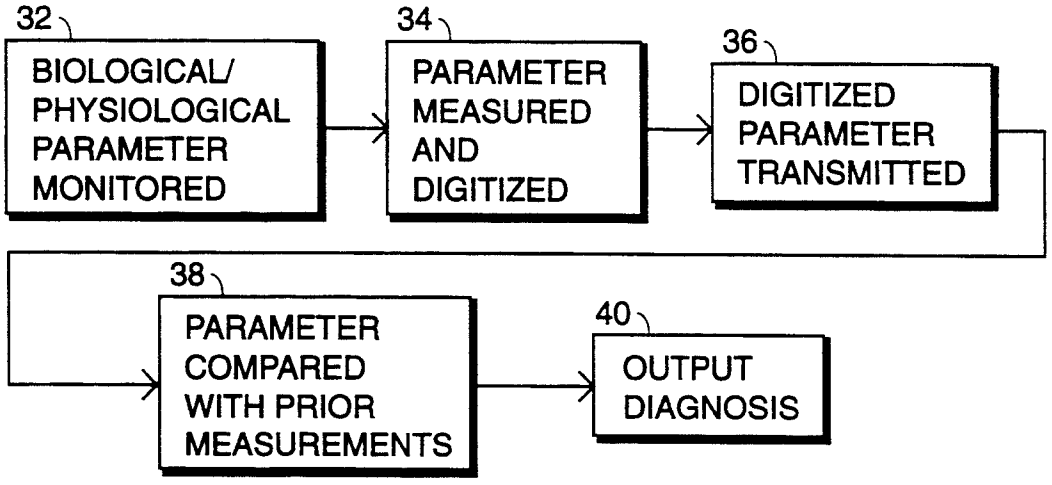


FIG. 2

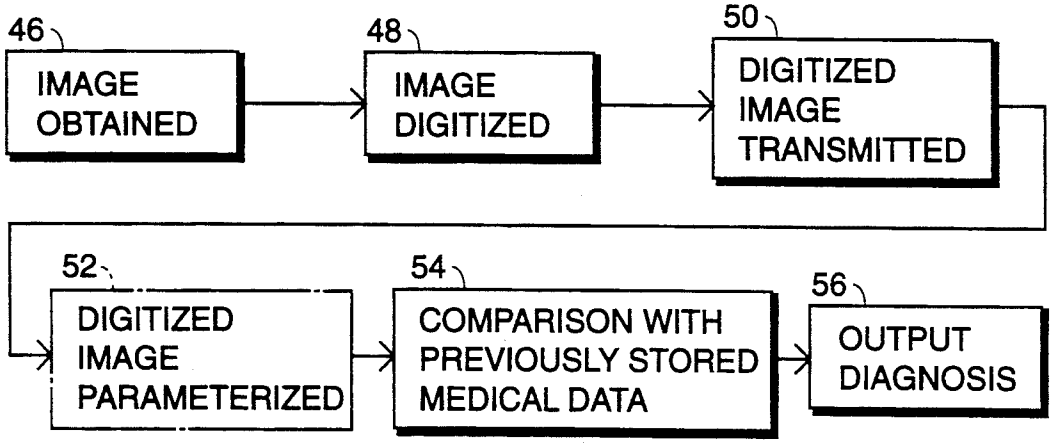


FIG. 3

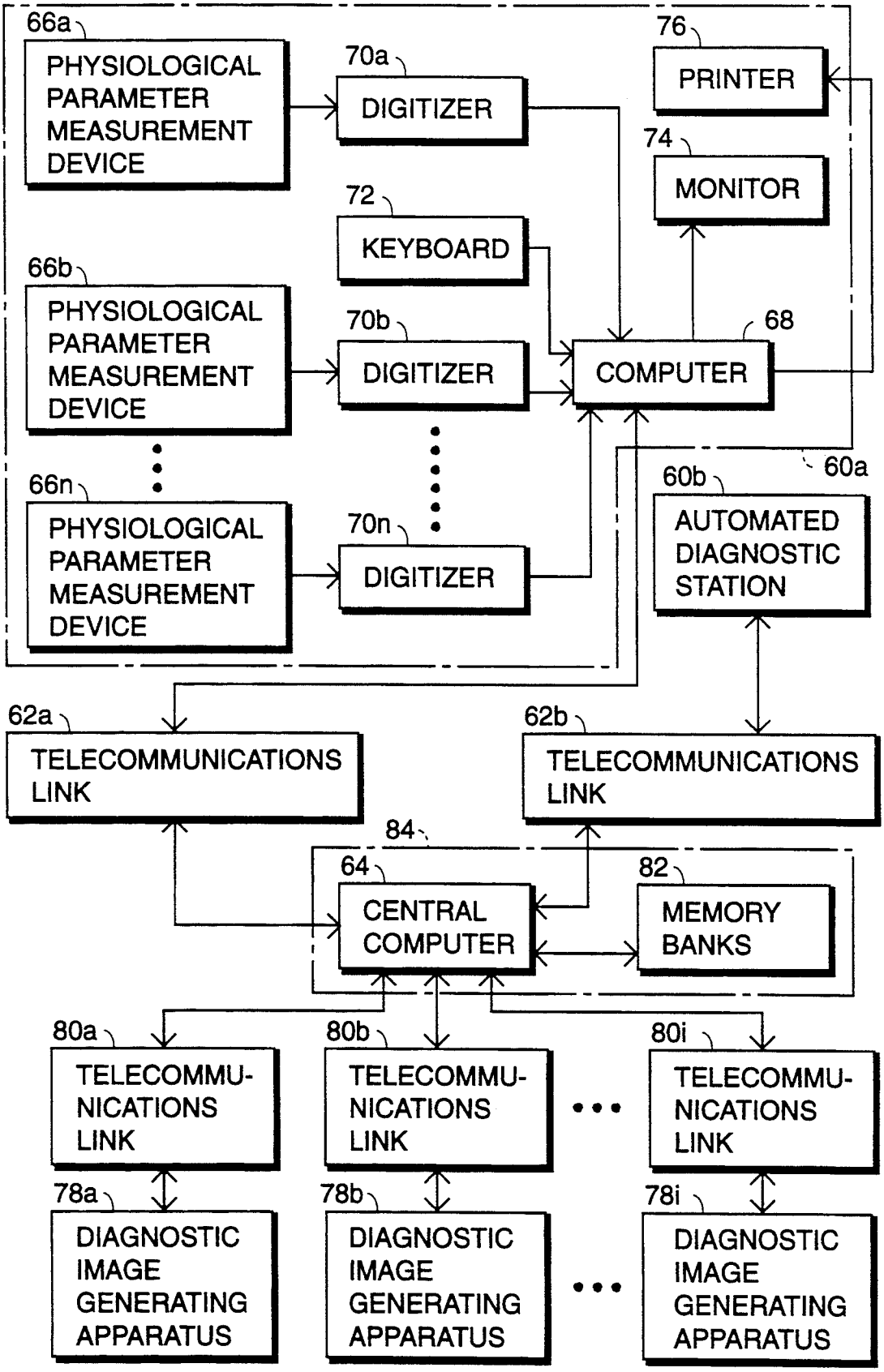

66a
PHYSIOLOGICAL PARAMETER MEASUREMENT DEVICE
70a
DIGITIZER
76
PRINTER
74
MONITOR
72
KEYBOARD
66b
PHYSIOLOGICAL PARAMETER MEASUREMENT DEVICE
70b
DIGITIZER
68
COMPUTER
66n
PHYSIOLOGICAL PARAMETER MEASUREMENT DEVICE
70n
DIGITIZER
60a
60b
AUTOMATED DIAGNOSTIC STATION
62a
TELECOMMUNICATIONS LINK
62b
TELECOMMUNICATIONS LINK
84
64
CENTRAL COMPUTER
82
MEMORY BANKS
80a
TELECOMMU-NICATIONS LINK
80b
TELECOMMU-NICATIONS LINK
80i
TELECOMMU-NICATIONS LINK
78a
DIAGNOSTIC IMAGE GENERATING APPARATUS
78b
DIAGNOSTIC IMAGE GENERATING APPARATUS
78i
DIAGNOSTIC IMAGE GENERATING APPARATUS

FIG. 4

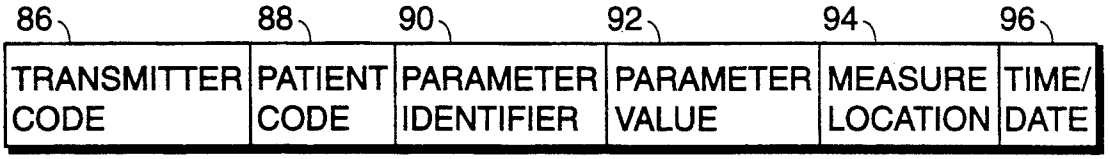


FIG. 5

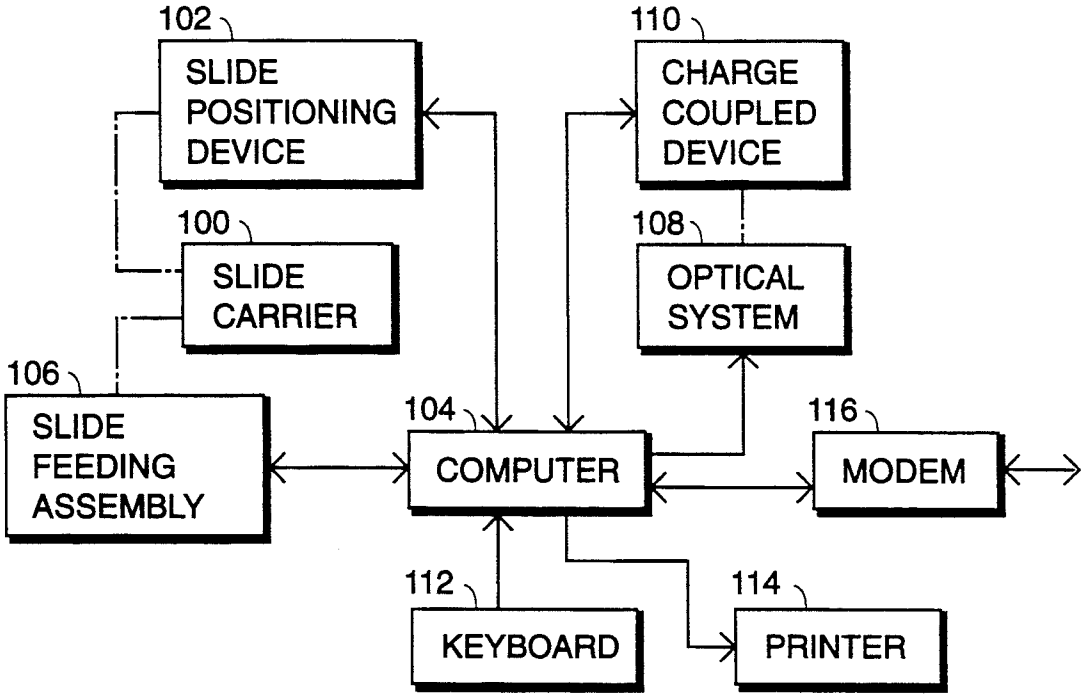


FIG. 6

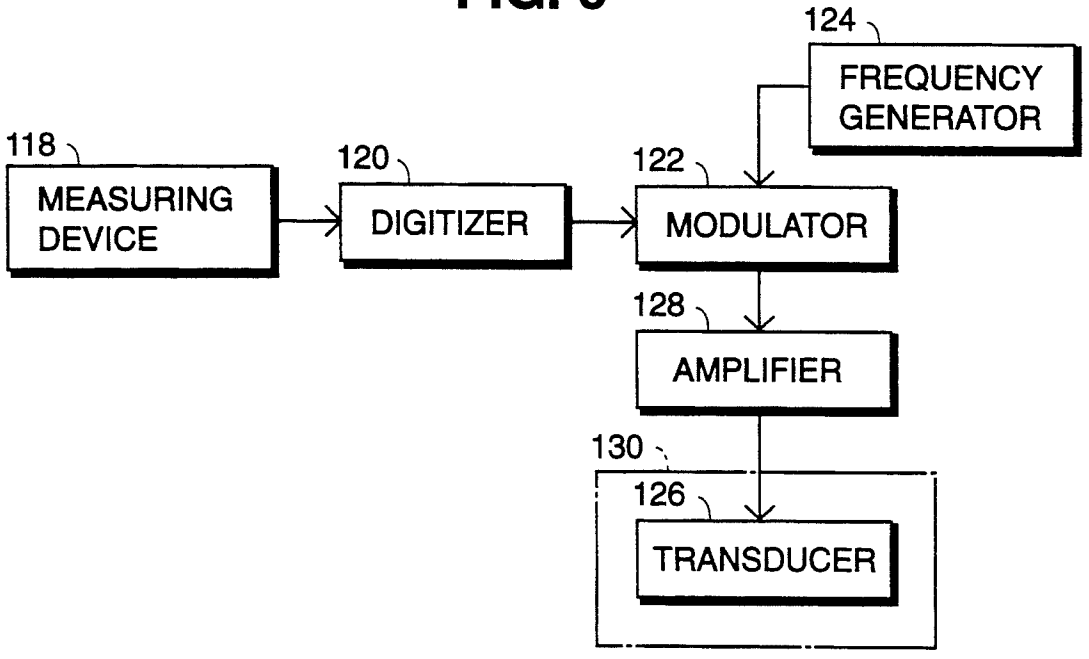


FIG. 7

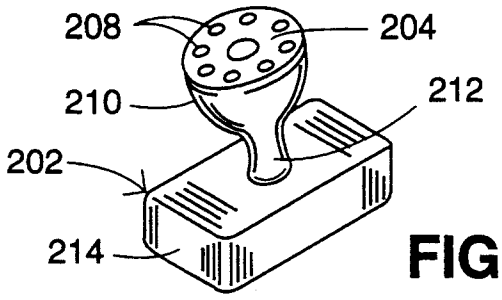

208
204
210
212
202
214

FIG. 8

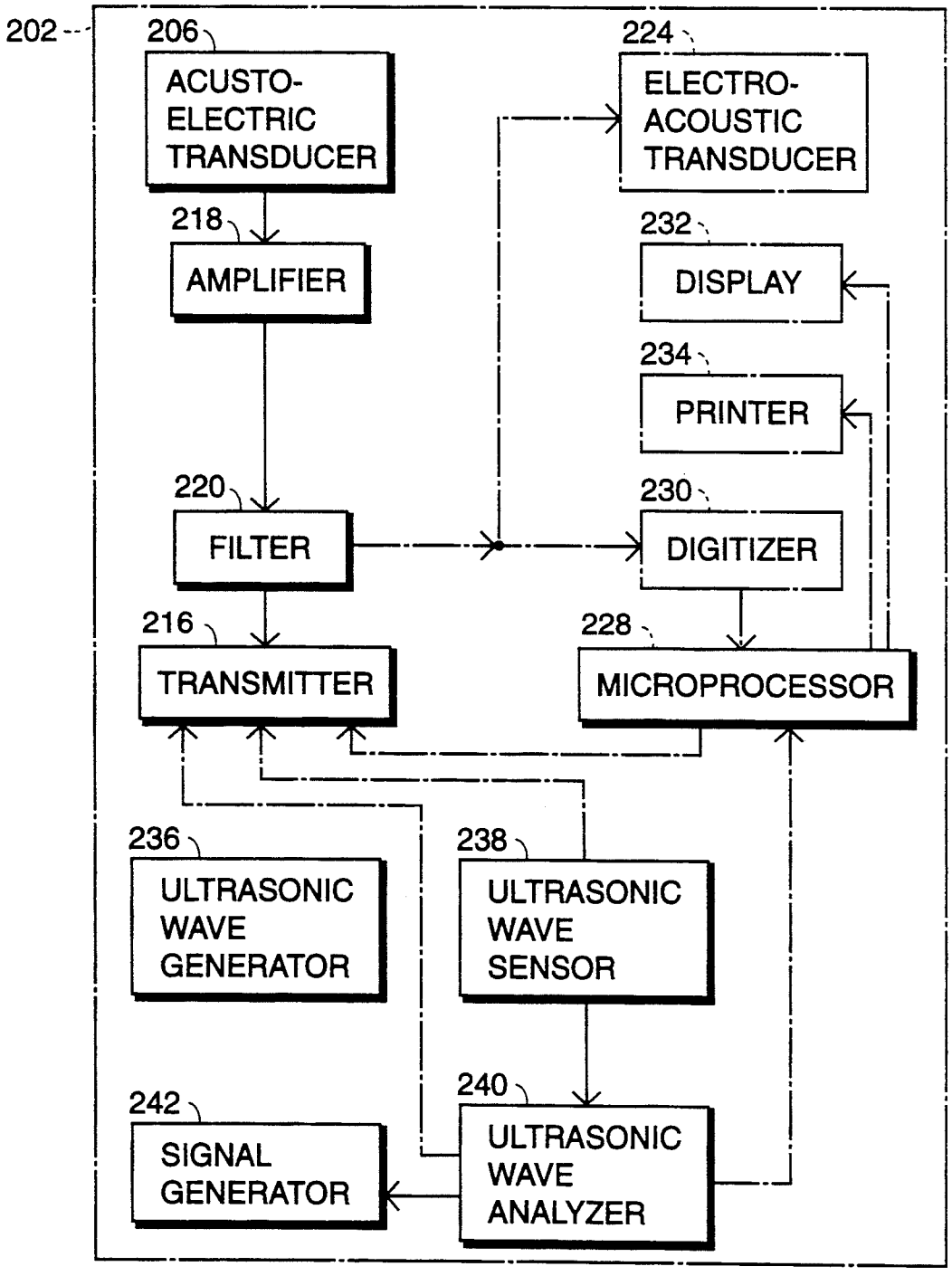

202
206
ACUSTO-ELECTRIC TRANSDUCER
224
ELECTRO-ACOUSTIC TRANSDUCER
218
AMPLIFIER
232
DISPLAY
234
PRINTER
220
FILTER
230
DIGITIZER
216
TRANSMITTER
228
MICROPROCESSOR
236
ULTRASONIC WAVE GENERATOR
238
ULTRASONIC WAVE SENSOR
240
242
SIGNAL GENERATOR
ULTRASONIC WAVE ANALYZER

FIG. 9

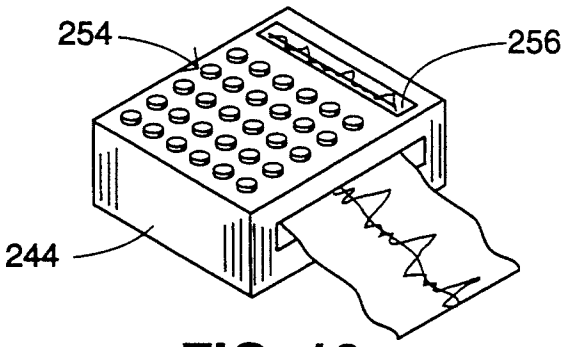

254
256
244

FIG. 10

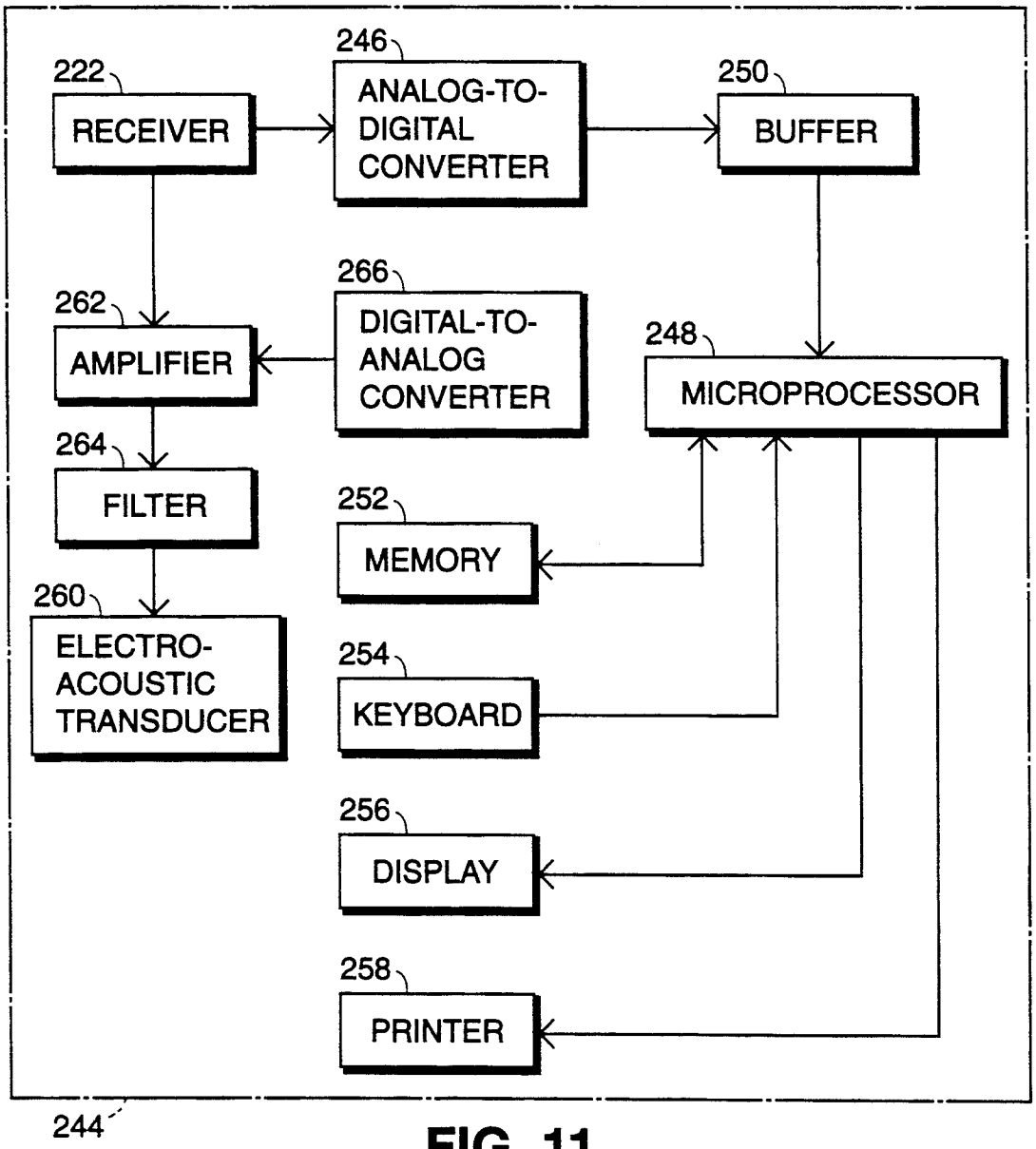

222
RECEIVER
246
ANALOG-TO-DIGITAL CONVERTER
250
BUFFER
262
AMPLIFIER
266
DIGITAL-TO-ANALOG CONVERTER
248
MICROPROCESSOR
264
FILTER
252
MEMORY
260
ELECTRO-ACOUSTIC TRANSDUCER
254
KEYBOARD
256
DISPLAY
258
PRINTER
244

FIG. 11

MEDICAL DIAGNOSIS DEVICE FOR SENSING CARDIAC ACTIVITY AND BLOOD FLOW

CROSS-REFERENCE TO A RELATED APPLICATION

This application is a continuation-in-part of commonly owned application Serial No. 819,120 filed Jan. 10, 1992.

BACKGROUND OF THE INVENTION

This invention relates to a device and an associated method for use in performing medical diagnoses.

A stethoscope is an instrument generally used for monitoring a person's heartbeat to detect irregularities in the functioning of the heart. The stethoscope is also frequently used to monitor the functioning of other organs such as the lungs.

The stethoscope has not changed much in the decades since its introduction into general use. A single user (a physician or nurse practitioner) listens through ear pieces to sounds originating within a patient and calls upon experience and training to interpret the meaning of the sounds.

OBJECTS OF THE INVENTION

An object of the present invention is to provide an improved medical instrument for monitoring acoustic frequency vibrations originating within a person.

Another object of the present invention is to provide such a medical instrument which permits the sensing of internal sounds simultaneously by a plurality of individuals.

Another, more particular, object of the present invention is to provide such a medical instrument which generates a visual display, readout or printout presenting information derived from acoustic frequency vibrations originating inside a person.

A further particular object of the present invention is to provide such a medical instrument which enables at least a partial automatic diagnosis of a patient's condition based upon acoustic or ultrasonic information.

Yet another object of the present invention is to provide a method for monitoring acoustic frequency vibrations originating within a person.

Another object of the present invention is to provide such a method which permits the sensing or monitoring of internal sounds simultaneously by a plurality of individuals.

Another, more particular, object of the present invention is to provide such a method which generates a visual display, readout or printout presenting information derived from acoustic frequency vibrations originating inside a person.

A further particular object of the present invention is to provide such a method which performs an at least partial automatic diagnosis of a patient's condition based upon acoustic or ultrasonic information.

SUMMARY OF THE INVENTION

A medical device comprises, in accordance with the present invention, a casing small enough to hold in one's hand and having a surface adapted for engagement with the skin of a patient, an acoustoelectric transducer mounted to the casing for sensing an acoustic vibration originating within a patient's body and for converting the sensed vibration to a first electrical signal, and a transmitter mounted to the casing and operatively coupled to the transducer for wirelessly transmitting, to a receiver, a second electrical signal incorporating information from the first electrical signal.

The medical device may further comprise an amplifier mounted to the casing and operatively coupled to the acoustoelectric transducer for amplifying the first electrical signal to produce an amplified electrical signal. An electroacoustic transducer is mounted to the casing and is operatively connected at an input to the amplifier for producing an acoustic pressure wave from the amplified electrical signal.

Thus, a plurality of individuals may simultaneously listen to a heart beat, breathing, or other cardiovascular or pulmonary activity. A filter may be mounted to the casing and operatively connected between the amplifier and the electroacoustic transducer for filtering predetermined frequencies from the amplified electrical signal prior to feeding thereof to the electroacoustic transducer.

Pursuant to another feature of the present invention, a processing circuit or analyzer is mounted to the casing and is operatively connected at an input to the acoustoelectric transducer and at an output to the transmitter for reducing, to at least one variable parameter, acoustic information contained in the first electrical signal and for feeding a third electrical signal encoding the parameter to the transmitter for transmission to the receiver.

Pursuant to an additional feature of the present invention, the hand held medical device further comprises an ultrasonic wave generator mounted to the casing for generating an ultrasonic pressure wave, an ultrasonic sensor mounted to the casing for monitoring reflected ultrasonic pressure waves returning to the casing upon generation of the waves by the wave generator, and an ultrasound processing circuit mounted to the casing and operatively connected to the sensor for analyzing reflected ultrasonic pressure waves detected by the sensor. An indicator is mounted to the casing and is operatively connected to the processing circuit for generating a signal sensible by an operator and indicating moving fluid such as blood moving through a blood vessel.

Alternatively, the ultrasonic sensor is operatively connected to the transmitter, whereby a signal encoding ultrasonic information from the sensor may be transmitted to a remote receiver. Such a remote receiver may be located in the same room as the hand held casing and may be disposed inside a housing having a size on the order of a cigarette pack.

A related medical device comprises, in accordance with the present invention, a casing small enough to hold in one's hand and having a surface adapted for engagement with the skin of a patient, an acoustoelectric transducer mounted to the casing for sensing an acoustic vibration originating within a patient's body and for converting the sensed vibration to a first electrical signal, an amplifier mounted to the casing and operatively coupled to the acoustoelectric transducer for amplifying the first electrical signal to produce an amplified electrical signal, and an electroacoustic transducer mounted to the casing and operatively connected at an input to the amplifier for producing an acoustic pressure wave from the amplified electrical signal.

As another feature of this related medical device, a processing circuit is mounted to the casing and is operatively connected at an input to the acoustoelectric transducer for reducing, to at least one variable parameter, acoustic information contained in the first electrical

signal and for generating an additional electrical signal encoding the parameter. The processing circuit is operatively connected to an output component mounted to the casing. The output component provides a sensible output of the derived parameter in response to the additional electrical signal. The output component may include a display or a printer which presents the derived parameter on a film material such as paper.

The derived parameter may have a continuously varying magnitude, such as represented in conventional pulse rate signals, electrical cardiograms etc. In that case, the visual display or printout may include a graph.

A medical device in accordance with another feature of the invention comprises a housing, a receiver mounted to the housing for receiving a wireless electrical signal encoding acoustic information originating inside a person, a memory, a processing circuit, and an oputput component. The memory is mounted to the housing and is operatively connected to the receiver for storing in electrically encoded form the acoustic information contained in the signal. The processing circuit is mounted to the casing and is operatively connected at an input to at least one of the receiver and the memory for reducing, to at least one variable parameter, acoustic information contained in the wireless electrical signal and for generating an additional electrical signal encoding the parameter. The output component is mounted to the housing and is operatively connected to the processing circuit for providing a sensible output of the parameter.

This medical device is preferably portable, and more preferably of a size that can be carried within a coat or breast pocket. The device receives a wireless signal from a hand held acoustic monitoring unit, performs at least a rudimentary analysis of the acoustic information contained in the wireless signal, and provides a preferably visual output of the derived or processed information. The output component may take the form of a small printer or a LCD type display. In this manner, a physician or other user can obtain immediate information in visually readable form, to reinforce or replace the acoustic type input from a conventional stethoscope. Thus, in accordance with the present invention, information is at least partially processed or analyzed prior to use by the physician. Moreover, as discussed in detail hereinafter, the portable medical device may contain a memory which stores previously collected information on the same patient. The prior graphs or parameterized data may be displayed or printed together with currently or recently collected data, thereby facilitating diagnosis as to a possibly changing condition. Furthermore, the memory may contain previously collected acoustic information from multiple patients, together with diagnoses of the acoustic symptoms. The portable medical device may thus provide automated diagnoses for the physician.

The portable medical diagnosis device may further comprise an amplifier mounted to the housing and operatively coupled to the receiver for generating an amplified signal containing the acoustic information. In that event, an electroacoustic transducer or speaker is mounted to the housing and is operatively connected at an input to the amplifier for producing an acoustic pressure wave from the amplified signal.

The amplifier may be operatively connected to the memory for amplifying an acoustic frequency signal stored therein. That acoustic frequency signal may have been recorded during a previous examination of the patient, for example, days, weeks or months prior.

According to another feature of the present invention, an input component such as a keyboard is mounted to the housing and is operatively connected to the memory for storing therein information identifying the person in whom the acoustic information originated.

A medical diagnostic method comprises, in accordance with the present invention, the steps of (a) automatically sensing an acoustic vibration inside a person, (b) converting the sensed acoustic vibration to an electrical signal, (c) amplifying the electrical signal, and (d) converting the amplified electrical signal to an acoustic pressure wave.

The steps of sensing and converting the sensed acoustic vibration to an electrical signal are generally implemented by operating an acoustoelectric transducer in a hand held device, and the method further comprises the step of holding the hand held device against a skin surface of the person.

The amplification of the electrical signal encoding acoustic information may be implemented by operating an amplifier in the hand held device, while conversion of the amplified electrical signal to an acoustic pressure wave is performed by operating an electroacoustic transducer mounted to the hand held device.

Alternatively, prior to or subsequently to the amplification of the electrical signal, it may be wirelessly transmitted to a receiver. The conversion to a pressure wave is then performed by operating an electroacoustic transducer connected to the receiver.

Pursuant to another feature of the present invention, the method further comprises the steps of wirelessly transmitting the amplified signal to a receiver and printing the acoustic information after the step of transmitting. The acoustic information or information derived therefrom during a processing step is advantageously printed in graphic form. In such a processing step, acoustic information contained in the electrical signal or amplified signal is analyzed to derive a value of at least one parameter related to the health of the person. The parameter is then displayed or printed in digital or graphic form.

Pursuant to another feature of the present invention, the medical method includes the step of storing acoustic information contained in the electrical signal.

An acoustic vibration which is the subject of the method may be cardiovascular in nature, for example, if the hand held device is placed against a person's skin near the heart or an artery, for example, in the perons's neck. Alternatively, the acoustic vibration may be pulmonary in nature.

Where the acoustic information pertains to the heart, a parameter obtained during automatic processing may be related to the rate and/or strength of the heart beat. A graphic display or printout of the heart beat contains peaks and valleys as in conventional cardiograms. Similar graphs may be produced as to pulmonary functioning or blood flow through an artery.

A medical instrument in accordance with the present invention for monitoring acoustic frequency vibrations originating within a person permits the sensing of internal sounds simultaneously by a plurality of individuals. Moreover, acoustic information is supplemented by a visual presentation. The visual information may be derived by automatically processing the electrical signal containing the acoustic information. Because information as to previous diagnoses may be stored and com-

pared with current acoustic input, the visual readings can provide diagnostic information, aiding the physician or other practitioner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of a medical diagnostic system.

FIG. **2** is a flow-chart diagram illustrating steps in a mode of operation of the diagnostic system of FIG. **1**.

FIG. **3** is a flow-chart diagram illustrating steps in another mode of operation of the diagnostic system of FIG. **1**.

FIG. **4** a block diagram of a further medical diagnostic system.

FIG. **5** is a diagram showing the composition of a data string or module used in the system of FIG. **4**.

FIG. **6** is a block diagram of a computerized slide scanning system.

FIG. **7** is a block diagram of a device for measuring a diagnostic parameter and transmitting the measurement over the telephone lines.

FIG. **8** is a schematic perspective view of a hand held acoustic monitoring device in accordance with the present invention.

FIG. **9** is a block diagram of functional components of the device of FIG. **8**.

FIG. **10** is schematic perspective view of a portable diagnostic and printout device which cofunctions with the device of FIG. **8** to provide readable results of acoustic measurements and automatic diagnoses, in accordance with the present invention.

FIG. **11** is a block diagram of functional components of the device of FIG. **10**.

DETAILED DESCRIPTION

As illustrated in FIG. **1**, a medical diagnostic system comprises a device **20** for monitoring and measuring a biological or physiological parameter. Monitoring and measuring device **20** is juxtaposable to a patient for collecting individualized medical data about the patient's condition. Device **20** may take the form of an electronic thermometer, an electronic blood pressure gauge, a pulmonary function apparatus, a doppler study apparatus, an EEG machine, an EKG machine, an EMG machine, a pressure measurement device, an acoustic sensor, etc., or include a plurality of such components.

Monitoring and measuring device **20** is connected at an output to a digitizer **22** which converts normally analog type signals into coded binary pulses and transmits the resulting digital measurement signal to a computer **24**. Digitizer **22** may be incorporated into a housing (not shown) enclosing all or part of the monitoring and measuring device **20**. Moreover, digitizer **22** may be an integral part of monitoring and measuring device **20**.

Computer **24** receives instructions and additional input from a keyboard **26**. Keyboard **26** is used to feed computer **24** information for identifying the patient, for example, the patient's age, sex, weight, and known medical history and conditions. Such medical conditions may include past diseases and genetic predispositions.

Computer **24** is also connected to an external memory **28** and an output device **30** such as a printer or monitor. Memory **28** stores medical data for a multiplicity of previously diagnosed medical conditions which are detectable by analysis of data provided by monitoring and measuring device **20**.

As illustrated in FIG. **2**, monitoring and measuring device **20** detects a magnitude of a predetermined biological or physiological parameter in a step **32**. Digitizer **22** converts the detected magnitude into a pre-established digital format in a step **34** and transmits the digital signal to computer **24** in a step **36**. Computer **24** is operated in a step **38** to compare the digitized data from monitoring and measuring device **20** with the data stored in memory **28** and to derive a diagnosis as to the patient's condition. The diagnosis is then communicated to the user (operator) and to the patient via output device **30** in a step **40**.

If monitoring and measuring device **20** measures a physiological function characterized by a plurality of different variables, for example, the electric potential at different points on the patient's body (EEG, EKG, EMG), these variables may be broken down by computer **24** into one or more parameters, e.g., a frequency packet. The measured values of the pre-established parameters are then compared with parameter ranges stored in memory **28** for the type of parameter and the kind of patient, as characterized by sex, age, weight, etc. If the measured values of the pre-established parameters fall within expected ranges, as stored in memory **28**, then computer **28** communicates a "normalcy" finding via printer **30**. If, on the contrary, the measured values of one or more parameters fall outside the normal ranges, then a diagnosis of a possible medical condition is printed out.

As further illustrated in FIG. **1**, the medical diagnostic system may comprise, in addition to or alternatively to monitoring and measuring device **20**, an image generating apparatus or scanner **42** for generating in electrically encoded form a visually readable image of an organic part of the patient. Scanner **42** may take the form of an MRI apparatus, a CAT scanner, an X-ray machine, an ultrasonography apparatus, or a video camera with or without magnification optics for magnifying a sample on a slide. The video camera can be used for obtaining an image of a portion of a patient's skin.

Scanner **42** is connected via an interface **44** to computer **24**.

As shown in FIG. **3**, scanner **42** obtains an image of a tissue or organ in a step **46**. The image is digitized, either by scanner **42** or interface **44** in a step **48**, and is transmitted to computer **24** in a step **50**. Computer **24** is operated in a step **52** to analyze the image from scanner **42** and determine specific values for a multiplicity of predetermined parameters. For example, in the event that scanner **42** takes the particular form of a video camera for dermatological diagnosis, an image of a skin surface of a patient is analyzed by computer **24** to derive such parameters as percentage of skin covered by abnormal condition, the range of sizes of individual ulcers, the range of color variation (e.g., whether bleeding is symptomatic).

The specific values of pre-established parameters calculated by computer **24** from electrically encoded images transmitted from scanner **42** are compared by computer **24** with previously determined parameter ranges stored in memory **28**. For example, if a pregnant woman's fetus is being scanned by ultrasonography, the lengths of the fetal appendages, arms, legs, fingers, etc., are compared with each other and with respective fetal appendage ranges recorded in memory **28** for the stage of pregnancy, weight of the fetus, and possibly weight of the mother. In the event that any appendages are missing or are of abnormal length, a diagnosis as to

possible deformity is printed out. Organs internal to the fetus may be similarly examined automatically by scanner **42** and computer **24**. In more advanced stages of pregnancy, physiological functions such as the heart rate of the fetus may be automatically monitored for abnormal conditions.

The analysis performed by computer **24** on the image from scanner **42** will depend in part on the region of the patient's body being scanned. If a woman's breast or a person's cortex is being monitored for tumorous growths, computer **24** is programmed to separate the tissue image into regions of different textures. The different textured regions are parameterized as to size, shape and location and the derived parameters are compared to values in memory **30** to determine the presence of a tumor. Additional analysis is undertaken to detect lines in an image which may indicate the presence of an organic body.

A similar analysis is undertaken to evaluate a tissue specimen on a slide. The texture and line scanning may be repeated at different magnification levels if, for example, the tissue sample is a slice of an organ wall. On a high magnification level, the texture and line analysis can serve to detect microorganisms in blood.

Memory **28** may store entire images related to different diseases. For example, memory may store images of skin conditions in the event that scanner **42** takes the form of a video camera at a dermatological diagnosis and treatment facility. In a step **54** (FIG. **3**), computer **24** compares the image of a patient's skin with previously stored images in memory **28**, for example, by breaking down the current image into sections and overlaying the sections with sections of the stored images, at variable magnification levels.

In the event that scanner **42** takes the form of an MRI apparatus or CAT scanner, the images stored in memory **28** are of internal organic structures. In step **54** (FIG. **3**), computer **24** compares images of a person's internal organs with previously stored organ images in memory **28**. Computer **24** partitions the image from the MRI apparatus or CAT scanner into subareas and overlays the subareas with sections of the stored images, at variable magnification levels.

In a final step **56** (FIG. **3**), computer **24** communicates the results of its diagnostic evaluation to a user or patient.

As illustrated in FIG. **4**, a medical diagnostic system comprises a plurality of remote automated diagnostic stations **60***a* and **60***b* connected via respective telecommunications links **62***a* and **62***b* to a central computer **64**. Each diagnostic station **60***a*, **60***b* may take the form shown in FIG. **1**, local computer **24** communicating via link **62***a*, **62***b* with central computer **64**. Alternatively, each diagnostic station **60***a*, **60***b* may take the form shown in FIG. **4** and include a respective plurality of monitoring and measuring devices **66***a*, **66***b* . . . **66***n* operatively connected to a local computer **68** via respective digitizer output units **70***a*, **70***b*, . . . **70***n*. Computer **68** is fed instructions and data from a keyboard **72** and communicates diagnostic results via a monitor **74** or printer **76**. As discussed hereinabove with reference to monitoring and measuring device **20** of FIG. **1**, each monitoring and measuring device **66***a*, **66***b*, . . . **66***n* is juxtaposable to a patient for collecting individualized medical data about the patient's condition. Monitoring and measuring devices **66***a*, **66***b*, . . . **66***n* may resepctively take the form of an electronic thermometer, an electronic blood pressure gauge, a pulmonary function apparatus, a doppler study apparatus, an EEG machine, an EKG machine, an EMG machine, a pressure measurement device, an acoustic sensor, etc.

Digitizers **70***a*, **70***b*, . . . **70***n* convert normally analog type signals into coded binary pulses and transmit the resulting digital measurement signals to computer **68**. Digitizers **70***a*, **70***b*, . . . **70***n* may be incorporated into the housings or casing (not shown) enclosing all or part of the respective monitoring and measuring devices **66***a*, **66***b*, . . . **66***n*.

Keyboard **72** is used to feed computer **68** information for identifying the patient, for example, the patient's age, sex, weight, and known medical history and conditions. Such medical conditions may include past diseases and genetic predispositions.

As further illustrated in FIG. **4**, a plurality of diagnostic image generating apparatuses or scanners **78***a*, **78***b*, . . . **78***i* are also connected to central computer **64** via respective telecommunications links **80***a*, **80***b*, . . . **80***i*. Scanners **78***a*, **78***b*, . . . **78***i* each generate in electrically encoded form a visually readable image of an organic part of the patient. Scanners **78***a*, **78***b*, . . . **78***i* may each take the form of an MRI apparatus, a CAT scanner, an X-ray machine, an ultrasonography apparatus, or a video camera with or without magnification optics for magnifying a sample on a slide.

Because of the enormous quantity of data necessary for storing images, central computer **64** is connected to a bank of memories **82** at a central storage and information processing facility **84**. Diagnosis of patient conditions may be undertaken by central computer **64** alone or in cooperation with local computers **24** or **68**.

As illustrated in FIG. **5**, local computers **24** and **68** transmit information to central computer **64** in data packets or modules each includes a first string of binary bits **86** representing the transmitting station **60***a*, **60***b*, a second bit string **88** identifying the patient, a bit group **90** designating the parameter which is being transmitted, another bit group **92** coding the particular measured value of the parameter, a set of bits **94** identifying the point on the patient at which the measurement was taken, and another bit set **96** carrying the time and date of the measurement. Other bit codes may be added as needed.

As shown in FIG. **6**, a computerized slide scanning system comprises a slide carrier **100** mountable to a microscope stage and a slide positioning device **102** mechanically linked to the slide carrier **100** for shifting the carrier along a path determined by a computer **104**. Computer **104** may be connected to an optional transport or feed assembly **106** which delivers a series of slides (not shown) successively to slide carrier **100** and removes the slides after scanning.

Computer **104** is also connected to an optical system **108** for modifying the magnification power thereof between successive slide scanning phases. Light emerging from optical system **108** is focused thereby onto a charge coupled device ("CCD") **110** connected to computer **104** for feeding digitized video images thereto.

Computer **104** performs a line and texture analysis on the digitized image information from CCD **110** to determine the presence of different organic structures and microorganisms. The different textured regions are parameterized as to size, shape and location and the derived parameters are compared to values in a memory to identify microscopic structures. The texture and line scanning is repeated at different magnification levels.

Computer **104** may be connected to a keyboard **112**, a printer **114**, and a modem **116**. Modem **116** forms part of a telecommunications link for connecting computer **104** to a remote data processing unit such as computer **64** in FIG. **4**.

Image generating apparatus **42** in Fig. **1** may take the form of the computerized slide scanning system of FIG. **6**.

As shown in FIG. **7**, a device for measuring a diagnostic parameter and transmitting the measurement over the telephone lines comprises a monitoring and measuring device **118** which may take the form, for example, of an electronic thermometer, an electronic blood pressure gauge, a pulmonary function apparatus, a doppler study apparatus, an EEG machine, an EKG machine, an EMG machine, a pressure measurement device, an acoustic sensor, etc., or include a plurality of such components. Monitoring and measuring device **118** is connected at an output to a digitizer **120** which in turn is coupled to a modulator **122**. Modulator **122** modulates a carrier frequency from a frequency generator **124** with the data arriving from monitoring and measuring device **118** via digitizer **120** and transmits the modulated signal to an electroacoustic transducer **126** via an amplifier **128**. Transducer **126** is removably attachable via a mounting element **130** to the mouthpiece of a telephone handset (not shown) and generates a pressure wave signal which is converted by a microphone in the handset mouthpiece back to an electrical signal for transmission over the telephone lines. Of course, transducer **126** may be omitted and modulator **122** connected directly to a telephone line.

The system of FIG. **7** enables the transmission of specialized medical data directly over the telephone lines to a central computer (e.g. computer **64** in Fig. **4**) which utilizes the incoming data to perform a diagnostic evaluation on the patient.

Monitoring and measuring device **118** may include traditional medical instrumentation such as a stethoscope or modern devices such as a CCD.

As illustrated in FIG. **8**, a medical device for monitoring acoustic frequency vibrations originating inside a patient comprises a casing **202** small enough to hold in one's hand and having a surface **204** adapted for engagement with the skin of the patient. As shown in FIG. **9**, an acoustoelectric transducer or microphone **206** is mounted to casing **202** in juxtaposition to apertures **208** in surface **204** for sensing an acoustic vibration originating within the patient's body and for converting the sensed vibration to an electrical signal.

Transducer **206** is disposed inside a substantially semispherical portion **210** (FIG. **8**) of casing **202** adapted for fitting within a physician's palm. A neck portion **212** of casing **202** connects semishperical portion **210** to a rounded prismatic body portion **214**. Prismatic body portion **214** is small enough to be grasped by a human hand, while casing **202** in its entirety is small enough to fit within a coat pocket.

The acoustic monitoring device of FIGS. **8** and **9** further comprises a transmitter **216** mounted to casing **202** and operatively coupled to transducer **206** via an amplifier **218** and a filter **220** for wirelessly transmitting, to a receiver **222** (FIG. **11**), an electrical or electromagnetic signal incorporating information from the signal at the output of transducer **206**.

Amplifier **218** is mounted to casing **202** and is operatively coupled to transducer **206** for amplifying the electrical signal from transducer **206** to produce an amplified electrical signal. Filter **220** is also mounted to casing **202** and is operatively coupled between amplifier **218** and transmitter **216** for filtering predetermined frequencies from the amplified electrical signal prior to feeding thereof to transmitter **216**.

The medical device of FIGS. **8** and **9** may be optionally provided with an electroacoustic transducer or speaker **224** mounted to casing **202** and operatively linked at an input to amplifier **218** via filter **220** for producing an acoustic pressure wave from the amplified electrical signal. That pressure wave essentially reproduces an acoustic frequency packet sensed by transducer **206**. Transducer **224** enables a plurality of individuals to simultaneously hear a heart beat, breathing, or other cardiovascular or pulmonary activity upon the juxtaposition of surface **204** to a patient's skin and upon activation of the device (power switch not shown).

Optionally, a microprocessor **228** is mounted to casing **202** and is tied at an input to acoustoelectric transducer **206** via amplifier **218**, filter **220**, and a digitizer or analog-to-digital converter **230**. Microprocessor **228** analyzes acoustic information in an incoming digitized electrical signal and reduces the acoustic information to values of at least one varying parameter. That information may be fed in electrically encoded form to transmitter **216** for wireless transmission to receiver **222** (FIG. **11**). Alternatively, the varying computed values of the physiological parameter may be displayed on a small LCD display **232** optionally incorporated into prismatic body portion **214** of casing **202**. If prismatic body portion **214** is large enough, it may additionally or alternatively incorporate a printer **234** for providing a graphic or digital printout of the processed acoustic information.

As further illustrated in FIG. **9**, the hand held medical device further comprises an ultrasonic wave generator **236** mounted to casing **202** for generating an ultrasonic pressure wave. An ultrasonic sensor **238** is provided in casing **202** for monitoring reflected ultrasonic pressure waves returning to the casing upon generation of the waves by wave generator **236**. An ultrasound processing circuit or wave analyzer **240** inside casing **202** is connected to sensor **238** for analyzing reflected ultrasonic pressure waves detected by the sensor. A signal generator **242** such as a dedicated speaker is connected to processing circuit **240** for generating a sound indicative of moving fluid such as blood moving through an artery in a patient's neck.

Alternatively, ultrasonic sensor **238** or processing circuit **240** is linked to transmitter **216**, whereby a signal encoding ultrasonic information may be transmitted to remote receiver **222**. Receiver **222** is generally located in the same room as the hand held casing **202**.

A medical device cooperating with the device of FIGS. **8** and **9** to produce, in visually readable form, information derived from acoustic vibrations within a person is illustrated in FIGS. **10** and **11**. A pocket size prismatic housing **244** carries receiver **222** which is adapted to receive a wireless electrical signal emitted by transmitter **216** (FIG. **9**). Housing **244** also contains a digitizer or analog-to-digital converter **246** which is connected to a microprocessor **248** via a buffer register **250**. Incoming electrical signals encoding acoustic information are stored by microprocessor **248** in a memory **252**. Memory **252** is sufficiently dense to store electrical signals encoding acoustic information previously collected via the components of FIGS. **9** and **11**.

Microprocessor **248** is connected at an input to a keyboard **254** by which identification information such as patient name and birth date may be entered and stored in memory **252**. Memory **252** is thereby capable of storing the results of acoustic measurements made at different times, separated, for example, by days, weeks or longer.

Mounted to housing **244** and contained therein are an LCD type display **256** and a printer **258**. In response to signals from microprocessor **248**, display **256** shows in digital or graphic form the values of heart rate and cardiovascular rhythms, in the event that the device of FIGS. **8** and **9** is used as a stethoscope to monitor cardiovascular activity.

Microprocessor **248** serves to reduce, to at least one variable parameter, acoustic information contained in the wireless electrical signal received by receiver **222** from transmitter **216**. For example, microprocessor **248** may be programmed to calculate the amount of energy in the acoustic transmissions from the patient. This energy is an indicator, for example, of cardiac activity where transducer **206** (FIG. **9**) is held to a patient's chest over the heart. In the instance where transducer **206** is juxtaposed to a skin surface over an artery, the energy indicator is a measure of blood flow through the artery and can be used to sense obstructions, aneurysms, etc.

Microprocessor **248** generates an electrical signal encoding the continuously computed parameter, whereby successive values of the parameter may be stored in memory **252**, displayed on display **256** or printed out via printer **258**. In addition, micro-processor **248** may be programmed to compute a more global indicator or parameter such as a heart rate value, or a magnitude indicative of heart beat regularity or rhythm. Such a global parameter may be shown as a digital value on display **256** or on a tabulation produced via printer **258**.

Through the use of the wireless stethoscope type device of FIGS. **8** and **9** and the cooperating receiver and output package of FIGS. **10** amd **11**, a physician or other user can obtain immediate information in visually readable form, to reinforce or replace acoustic information of the type obtainable from a conventional stethoscope. In addition, that visually decipherable diagnostic information, as well as amplified acoustic information from speaker **224** (FIG. **9**) or a speaker **260** in housing **244**, is available to more than one individual simultaneously, thereby enabling immediate consultation between a plurality of physicians or other practitioners.

Speaker or electroacoustic transducer **260** receives input from receiver **222** via an amplifier **262** and a filter **264**. That input is converted in real time to audible pressure waves. Where speaker **260** is provided, transducer **224** (FIG. **9**) may be omitted. Speaker **260** is also operatively connected via amplifier **262**, filter **264** and a digital-to-analog converter **266** to memory **252**, whereby, under the control of microprocessor **248**, speaker **260** is empowered to play back sounds previously recorded in the memory, such as prior cardiovascular sounds of a same patient.

Memory **252** naturally stores successive values of the acoustic parameters calculated via processing operations in microprocessor **248**. This parameterized or processed information is also avaliable for subsequent production on display **256** or via printer **258**, advantageously in juxtaposition with recently recorded and processed information. Thus, a physician is able to immediately compare a current measurement with a prior measurement of heart, lung or other internal activity of the same patient. Of course, the information is organized in memory **252** by microprocessor **248** in accordance with identification information fed to the microprocessor via keyboard **254**.

As discussed in detail hereinabove with reference generally to FIGS. **1–7**, memory **252** may store previously collected acoustic information from multiple patients, together with diagnoses of the acoustic symptoms. Thus, microprocessor **248** accessing the records in memory **252** may provide automated diagnoses for consideration by the physician in arriving at his or her diagnoses.

Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proferred by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

What is claimed is:

1. A medical device comprising:

a casing small enough to hold in one's hand, said casing having a surface adapted for engagement with the skin of a patient;

acoustoelectric transducer means mounted to said casing for sensing an acoustic vibration originating within the patient and for converting the sensed vibration to a first electrical signal;

transmitter means mounted to said casing and operatively coupled to said transducer means for wirelessly transmitting, to a receiver, a second electrical signal incorporating information from said first electrical signal;

ultrasonic wave generating means mounted to said casing for generating an ultrasonic pressure wave; and

ultrasonic sensor means mounted to said casing for detecting a reflected ultrasonic pressure wave returning to said casing upon generation of said wave by said wave generating means, said transmitter means being operatively connected to said sensor means for transmitting a signal encoding ultrasonic information from said sensor means.

2. The device defined in claim **1**, further comprising amplification means mounted to said casing and operatively coupled to said acoustoelectric transducer means for amplifying said first electrical signal to produce an amplified electrical signal, also comprising electroacoustic transducer means mounted to said casing and operatively connected at an input to said amplification means for producing an acoustic pressure wave from said amplified electrical signal.

3. The device defined in claim **2**, further comprising filter means mounted to said casing and operatively connected between said amplification means and said electroacoustic transducer means for filtering predetermined frequencies from said amplified electrical signal prior to feeding thereof to said electroacoustic transducer means.

4. The device defined in claim **1**, further comprising analyzing means mounted to said casing and operatively connected at an input to said transducer means and at an output to said transmitter means for reducing, to at least

one variable parameter, acoustic information contained in said first electrical signal and for generating a third electrical signal encoding said parameter and feeding said third electrical signal to said transmitter means for transmission to said receiver.

5. The device defined in claim 1, further comprising modulator means operatively connected to said acoustoelectric transducer means and said transmitter means for modulating said second electrical signal with said first electrical signal.

6. The device defined in claim 1 wherein said casing includes a holder portion adapted for a manual grasping and another portion with said surface.

7. A medical device comprising:

a casing small enough to hold in one's hand, said casing having a surface adapted for engagement with the skin of a patient;

acoustoelectric transducer means mounted to said casing for sensing an acoustic vibration originating within the patient and for converting the sensed vibration to a first electrical signal;

transmitter means mounted to said casing and operatively coupled to said transducer means for widely transmitting, to a receiver, a second electrical signal incorporating information from said first electrical signal;

ultrasonic wave generating means mounted to said casing for generating an ultrasonic pressure wave;

ultrasonic sensor means mounted to said casing for detecting a reflected ultrasonic pressure wave returning to said casing upon generation of said wave by said wave generating means;

ultrasound analyzing means mounted to said casing and operatively connected to said sensor means for analyzing the reflected ultrasonic pressure wave detected by said sensor means; and

indicator means mounted to said casing and operatively connected to said analyzing means for generating a signal sensible by an operator and indicating moving fluid.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,360,005
DATED : November 1, 1994
INVENTOR(S) : Peter J. Wilk

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 6, line 25, replace "28" with --24--.

Column 7, line 15, replace "30" with --28--; line 26, insert --28-- after "memory".

Column 8, line 36, insert --,-- after "modules", replace "includes" with --including--.

Column 11, line 41, replace "amd" with --and--.

Column 14, line 4, claim 7, replace "widely" with --wirelessly--.

Signed and Sealed this

Thirtieth Day of May, 1995

Attest:

Attesting Officer

BRUCE LEHMAN

Commissioner of Patents and Trademarks